

Proposing a New Foundation of Attack Trees in Monoidal Categories

Harley Eades III

Computer and Information Sciences, Augusta University, Augusta, GA,
heades@augusta.edu

Abstract. TODO

- 1 Introduction
- 2 Attack Trees
- 3 Concrete Semantics of Attack Trees in Dialectica Spaces
- 4 Abstract Semantics of Attack Trees in Monoidal Categories
- 5 Reasoning about Attack Trees in Linear Logic

References

1. Nick Benton. A mixed linear and non-linear logic: Proofs, terms and models (preliminary report). Technical Report UCAM-CL-TR-352, University of Cambridge Computer Laboratory, 1994.
2. R. F. Blute, J.R.B. Cockett, R.A.G. Seely, and T. H. Trimble. Natural deduction and coherence for weakly distributive categories. *Journal of Pure and Applied Algebra*, 113(3):229–296, 1996.
3. Carolyn Brown, Doug Gurr, and Valeria Paiva. A linear specification language for petri nets. *DAIMI Report Series*, 20(363), 1991.
4. Luís Caires and Frank Pfenning. Session types as intuitionistic linear propositions. In Paul Gastin and François Laroussinie, editors, *CONCUR 2010 - Concurrency Theory*, volume 6269 of *Lecture Notes in Computer Science*, pages 222–236. Springer Berlin Heidelberg, 2010.
5. S.A. Camtepe and B. Yener. Modeling and detection of complex attacks. In *Security and Privacy in Communications Networks and the Workshops, 2007. SecureComm 2007. Third International Conference on*, pages 234–243, Sept 2007.
6. Chris Casinghino, Vilhelm Sjöberg, and Stephanie Weirich. Step-indexed normalization for a language with general recursion. In *Proceedings Fourth Workshop on Mathematically Structured Functional Programming*, 2012.
7. S. Convery, D. Cook, and M. Franz. An attack tree for the border gateway protocol. 2003. <https://tools.ietf.org/html/draft-ietf-rpsec-bgpattack-00>.

8. Valeria de Paiva. Dialectica and chu constructions: Cousins? *Theory and Applications of Categories*, 17(7):127–152, 2006.
9. Valeria de Paiva. Categorical semantics of linear logic for all. In Luiz Carlos Pereira, Edward Hermann Haeusler, and Valeria de Paiva, editors, *Advances in Natural Deduction*, volume 39 of *Trends in Logic*, pages 181–192. Springer Netherlands, 2014.
10. The Coq development team. The coq proof assistant reference manual. LogiCal Project, 2015. Version 8.4.
11. Lucas Dixon, Ross Duncan, and A. Kissinger. Open graphs and computational reasoning. *Extended Abstract: Developments in Computational Models*, 2010.
12. Lucas Dixon and Aleks Kissinger. Open-graphs and monoidal theories. May 2011.
13. Harley D. Eades III and Aaron Stump. Hereditary substitution for the $\lambda\Delta$ -calculus. In Ugo de'Liguoro and Alexis Saurin, editors, *Proceedings First Workshop on Control Operators and their Semantics*, Eindhoven, The Netherlands, June 24–25, 2013, volume 127 of *Electronic Proceedings in Theoretical Computer Science*, pages 45–65. Open Publishing Association, 2013.
14. Harley D. Eades III. *The Semantic Analysis of Advanced Programming Languages*. PhD thesis, University of Iowa, 2014.
15. Harley D. Eades III and Aaron Stump. Hereditary substitution for stratified system f. *Proof-Search in Type Theories (PSTT)*, 2010.
16. Harley Eades III and Valeria de Paiva. Multiple conclusion intuitionistic linear logic and cut elimination. <http://metatheorem.org/papers/FILL-report.pdf>.
17. Ravi Jhawar, Barbara Kordy, Sjouke Mauw, SaĀ!a RadomiroviĀ, and Rolando Trujillo-Rasua. Attack trees with sequential conjunction. In Hannes Federrath and Dieter Gollmann, editors, *ICT Systems Security and Privacy Protection*, volume 455 of *IFIP Advances in Information and Communication Technology*, pages 339–353. Springer International Publishing, 2015.
18. Garrin Kimmell, Aaron Stump, Harley D. Eades III, Peng Fu, Tim Sheard, Stephanie Weirich, Chris Casinghino, Vilhelm Sjöberg, Nathan Collins, and Ki Yung Ahn. Equational reasoning about programs with general recursion and call-by-value semantics. *Programming Languages Meets Program Verification (PLPV)*, 2012.
19. Garrin Kimmell, Aaron Stump, Harley D. Eades III, Peng Fu, Tim Sheard, Stephanie Weirich, Chris Casinghino, Vilhelm Sjöberg, Nathan Collins, and Ki Yung Ahn. Equational reasoning about programs with general recursion and call-by-value semantics. *Special issue of Progress in Informatics*, March 2013.
20. Barbara Kordy, Marc Pouly, and Patrick Schweitzer. Computational aspects of attack–defense trees. In Pascal Bouvry, Mieczysław A. Kłopotek, Franck Leprévost, Małgorzata Marciniak, Agnieszka Mykowiecka, and Henryk Rybiński, editors, *Security and Intelligent Information Systems*, volume 7053 of *Lecture Notes in Computer Science*, pages 103–116. Springer Berlin Heidelberg, 2012.
21. Barbara Kordy, Marc Pouly, and Patrick Schweitzer. A probabilistic framework for security scenarios with dependent actions. In Elvira Albert and Emil Sekerinski, editors, *Integrated Formal Methods*, volume 8739 of *Lecture Notes in Computer Science*, pages 256–271. Springer International Publishing, 2014.
22. J. Lambek. From lambda calculus to cartesian closed categories. *To H. B. Curry: Essays on Combinatory Logic, Lambda Calculus and Formalism*, pages 376–402, 1980.
23. Saunders Mac Lane. *Categories for the Working Mathematician*. Number 5 in Graduate Texts in Mathematics. Springer-Verlag, 1971.

24. Sjouke Mauw and Martijn Oostdijk. Foundations of attack trees. In DongHo Won and Seungjoo Kim, editors, *Information Security and Cryptology - ICISC 2005*, volume 3935 of *Lecture Notes in Computer Science*, pages 186–198. Springer Berlin Heidelberg, 2006.
25. J. P. McDermott. Attack net penetration testing. In *Proceedings of the 2000 Workshop on New Security Paradigms*, NSPW '00, pages 15–21, New York, NY, USA, 2000. ACM.
26. Ulf Norell. Dependently typed programming in agda. In *Proceedings of the 4th international workshop on Types in language design and implementation*, TLDI '09, pages 1–2, New York, NY, USA, 2009. ACM.
27. Benjamin C. Pierce and David N. Turner. Local type inference. *ACM Trans. Program. Lang. Syst.*, 22(1):1–44, January 2000.
28. L. Piètre-Cambacédès and M. Bouissou. Beyond attack trees: Dynamic security modeling with boolean logic driven markov processes (bdmp). In *Dependable Computing Conference (EDCC), 2010 European*, pages 199–208, April 2010.
29. Vaughan Pratt. Chu spaces. Notes for the School on Category Theory and Applications University of Cimbra, July 1999.
30. A. Reinhardt, D. Seither, A. König, R. Steinmetz, and M. Hollick. Protecting iee 802.11s wireless mesh networks against insider attacks. In *Local Computer Networks (LCN), 2012 IEEE 37th Conference on*, pages 224–227, Oct 2012.
31. Bruce Schneier. Attack trees: Modeling security threats. *Dr. Dobbs's journal*, December 1999.
32. R.A.G. Seely. Polymorphic linear logic and topos models. *C.R. Math. Rep. Acad. Sci. Canada*, XII(1), February 1990.
33. Peter Selinger. A survey of graphical languages for monoidal categories. *ArXiv e-prints*, August 2009.
34. Vilhelm Sjöberg, Chris Casinghino, Ki Yung Ahn, Nathan Collins, Harley D. Eades III, Peng Fu, Garrin Kimmell, Tim Sheard, Aaron Stump, and Stephanie Weirich. Irrelevance, heterogeneous equality, and call-by-value dependent type systems. In James Chapman and Paul Blain Levy, editors, *Proceedings Fourth Workshop on Mathematically Structured Functional Programming*, Tallinn, Estonia, 25 March 2012, volume 76 of *Electronic Proceedings in Theoretical Computer Science*, pages 112–162. Open Publishing Association, 2012.
35. Vilhelm Sjöberg and Stephanie Weirich. Programming up to congruence. In *Proceedings of the 42Nd Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages*, POPL '15, pages 369–382, New York, NY, USA, 2015. ACM.
36. Chee-Wooi Ten, Chen-Ching Liu, and Manimaran Govindarasu. Vulnerability assessment of cybersecurity for scada systems using attack trees. In *Power Engineering Society General Meeting, 2007. IEEE*, pages 1–8, June 2007.
37. A Tzouvaras. The linear logic of multisets. *Logic Journal of IGPL*, 6(6):901–916, 1998.
38. Philip Wadler. Propositions as sessions. In *Proceedings of the 17th ACM SIGPLAN International Conference on Functional Programming*, ICFP '12, pages 273–286, New York, NY, USA, 2012. ACM.
39. Kevin Watkins, Ilario Cervesato, Frank Pfenning, and David Walker. A concurrent logical framework: The propositional fragment. In Stefano Berardi, Mario Coppo, and Ferruccio Damiani, editors, *Types for Proofs and Programs*, volume 3085 of *Lecture Notes in Computer Science*, pages 355–377. Springer Berlin / Heidelberg, 2004.

40. J.B. Wells. Typability and type checking in system f are equivalent and undecidable. *Annals of Pure and Applied Logic*, 98(1&3):111 – 156, 1999.

A Source Sink Graphs are Symmetric Monoidal